SIZING

To properly size a BM TEFC Motor air-cooled oil cooler for industrial equipment, you should first determine some basic parameters associated with your system.

HEAT LOAD

In many instances the heat load must be determined by using a "total potential" method. This total potential or horse power method is the most common method, and is the simplest way to determine basic heat rejection requirements for hydraulic systems. The total potential is equal to the maximum operating flow and pressure that are generated by the system under full load. To determine the total potential (HP) use the following formula. Note: If the electric motor horsepower of the system prime mover is known, use it as your system potential.

HP = [System Pressure (PSI) x System flow (GPM)] / 1714

Examples:
(1) 7.5 HP 254T frame electric motor driving a pump = 7.50 HP potential
(1) HP = (1250 PSI x 10 GPM) / 1714 = 7.30 HP or the total input potential

To determine the system heat load in BTU / HR we must use a percentage *(v)* of the system potential HP. The factor *(v)* can be calculated by adding up the actual inefficencies of a system; however, for most applications a *(v)* value of 25% - 30% can be used.

Example: 7.50 HP x .30 = 2.25 HP heat

To convert the horsepower of heat into BTU/HR use the formula below:
HP x 2542 = BTU/HR

Example: 2.25 HP Heat x 2545 = 5,729 BTU/HR

Applying into a return line

For most open loop systems with vane or gear type fixed delivery pumps. To calculate the Fs value required when applying the air/oil cooler into a return line use the formula below:

$$Fs = \frac{BTU/HR \times Cv}{T - t_{ambient}} \qquad \text{Example} = \frac{5729 \times 1.08}{140 - 90} = 123.7\ Fs$$

T = Desired system oil temperature leaving the cooler °F
$t_{ambient}$ = Ambient air temperature entering the cooler °F
Cv = Correction factor for oil viscosity. Example: ISO32 oil @140°F = 1.08 *(see chart)*

APPLYING INTO A CASE LINE

In circumstances where the system is a closed loop, or when return line flow is not available, the case drain flow can be utilized to help cool the system. However, in many instances, the case drain flow alone will not be enough to reject all of the heat generated by the system. Case drain lines should not be treated as a normal return lines since the pressure drop allowable usually can vary from 2 - 10 PSI max. Check with your pump manufacturer for the appropriate pressure drop tolerance before applying any cooler. To size the system for case flow or case flow plus any additional flushing loops, please use the following method. Closed loop case drain operating temperatures are normally higher than open loop circuit return line temperatures.

Formula

$$Tc_{exit} = \{ T - [Q / (\text{case flow gpm} \times 210)]\}$$

Example

$$Tc_{exit} = \{ 155 - [5,729 / (3 \times 210)]\} = 145.9$$

Tc_{exit} = The corrected temperature of the oil exiting the cooler.

$$Fs = \frac{Q \times Cv}{Tc_{exit} - t_{ambient}} \qquad \frac{5,729 \times 1.08}{145.9 - 90} = 101.6$$

SELECTION

To select a model, locate the flow rate (GPM) at the bottom of the flow vs Fs graph. Proceed upward until the GPM intersects with the calculated Fs. The curve closest above the intersection point will meet these conditions.

Examples:

Return Line	Case Drain
Fs = 123.7	Fs = 101.6
GPM = 10 "return line flow"	GPM = 3.0
Motor size = 324 frame	Motor size = 254T frame
Model = BM - 321	Model = BM - 302

PRESSURE DROP

Determine the oil pressure drop from the curves as indicated. For viscosities other than 50 sus at operating, multiply the actual indicated pressure drop (psi) for your GPM by the value in the pressure differential chart for your viscosity.

Examples:	GPM = 10	GPM = 3
Indicated pressure drop	1.4 PSI	1 PSI
Cp correction factor for *ISO 32 oil @ 140°F*	1.23	1.23
Pressure drop correction	1.4x1.23 = 1.72 psi	1.0x1.23 = 1.23 psi

AIR FLOW CORRECTION CHART

In some instances our units are applied to motors or application where additional or less air flow is available than the flows used for our performance curves. In these instances you can use our air flow correction curves to determine if one of the existing models will work for your application.

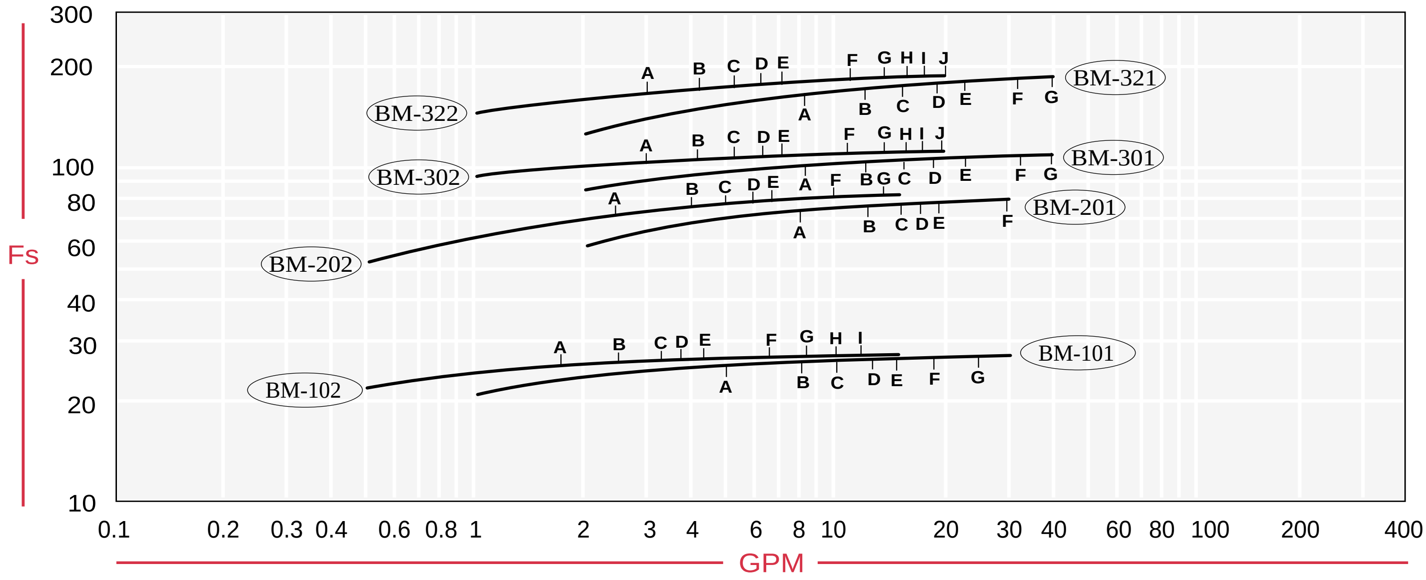
Example:
Follow the preceding examples to properly determine your required Fs. Use the following formula to correct for the difference in air-flow rate. If the calculated Fs = 123.7 and the electric motor were a 1800 rpm 326 frame motor with 250 cfm of air flow, correct as shown. Select the correction factor Cf only from the curve that matches to your electric motor frame size properly. Note: Using a unit that is to small may damage your electric motor due to lack adequate of air flow.

Formula	Example
Fs x C*f* = CFs (corrected)	CFs = 123.7 x 1.50 (from curve) = 185.6 CFs

Average Liquid Temperature	Cv VISCOSITY CORRECTION FACTORS																
	SAE 5	SAE 10	SAE 20	SAE 30	SAE 40	ISO 22	ISO 32	ISO 46	ISO 68	ISO 100	ISO 150	ISO 220	ISO 320	MIL-L 7808	POLY-GLYCOL	PHOS-PHATE ESTER	50% ETHY-LENE GLYCOL &WATER
100	1.11	1.15	1.25	1.38	1.45	1.08	1.14	1.18	1.26	1.37	1.43	1.56	1.84	1.19	0.92	0.83	0.85
110	1.09	1.12	1.20	1.32	1.40	1.06	1.13	1.16	1.25	1.31	1.39	1.48	1.67	1.14	0.89	0.80	0.84
120	1.06	1.10	1.17	1.27	1.35	1.04	1.11	1.14	1.20	1.27	1.35	1.40	1.53	1.09	0.88	0.79	0.84
130	1.04	1.08	1.13	1.24	1.29	1.03	1.09	1.13	1.17	1.24	1.30	1.34	1.44	1.05	0.85	0.77	0.83
140	1.03	1.05	1.11	1.19	1.25	1.02	1.08	1.10	1.16	1.20	1.26	1.30	1.39	1.03	0.84	0.76	0.82
150	1.01	1.04	1.09	1.16	1.22	1.02	1.06	1.09	1.13	1.17	1.22	1.27	1.33	1.01	0.83	0.74	0.82
200	0.98	0.99	1.01	1.04	1.07	0.98	0.99	1.00	1.01	1.02	1.08	1.09	1.14	0.98	0.79	0.71	0.80
250	0.95	0.96	0.97	0.98	0.99	0.95	0.96	0.96	0.96	0.97	0.99	1.01	1.02	0.97	0.76	0.69	0.79

Average Liquid Temperature	Cp PRESSURE DROP CORRECTION FACTORS																
	SAE 5	SAE 10	SAE 20	SAE 30	SAE 40	ISO 22	ISO 32	ISO 46	ISO 68	ISO 100	ISO 150	ISO 220	ISO 320	MIL-L 7808	POLY-GLYCOL	PHOS-PHATE ESTER	50% ETHY-LENE GLYCOL &WATER
100	2.00	2.40	4.40	6.40	8.80	1.07	1.53	1.82	2.54	4.19	6.44	9.38	13.56	1.26	3.00	3.50	0.730
110	1.70	2.10	3.60	5.10	6.70	1.04	1.45	1.72	2.35	3.73	5.70	8.33	11.63	1.20	2.40	2.90	0.720
120	1.50	1.80	3.00	4.20	5.60	1.02	1.38	1.60	2.15	3.26	4.91	7.23	9.73	1.14	2.10	2.50	0.709
130	1.40	1.60	2.60	3.40	4.50	0.99	1.30	1.49	1.94	2.80	4.14	6.19	7.80	1.08	1.90	2.20	0.698
140	1.30	1.50	2.23	2.90	3.70	0.97	1.23	1.38	1.75	2.38	3.47	5.20	6.11	1.03	1.90	2.00	0.686
150	1.20	1.30	1.90	2.50	3.10	0.95	1.17	1.30	1.61	2.04	2.90	4.35	4.77	0.98	1.70	1.90	0.676
200	0.93	0.96	1.20	1.40	1.60	0.89	0.99	1.08	1.18	1.33	1.59	1.74	1.95	0.90	1.20	1.30	0.635
250	0.81	0.82	0.92	0.97	1.05	0.85	0.93	0.96	1.03	1.11	1.21	1.22	1.23	0.83	1.00	1.05	0.556

BM SERIES



PERFORMANCE CALCULATION
$F_s = \dfrac{\text{Horsepower to be removed (HP) x 2545 x Cv}}{\text{°F (Oil Leaving* - Ambient Air Entering)}} = \dfrac{\text{BTU}}{\text{hr °F}}$

*Represents desired fluid leaving the cooler.

OIL PRESSURE DROP (PSI) CODE			
A = 1 PSI	D = 4 PSI	G = 15 PSI	J = 30 PSI
B = 2 PSI	E = 5 PSI	H = 20 PSI	K = 35 PSI
C = 3 PSI	F = 10 PSI	I = 25 PSI	L = 40 PSI

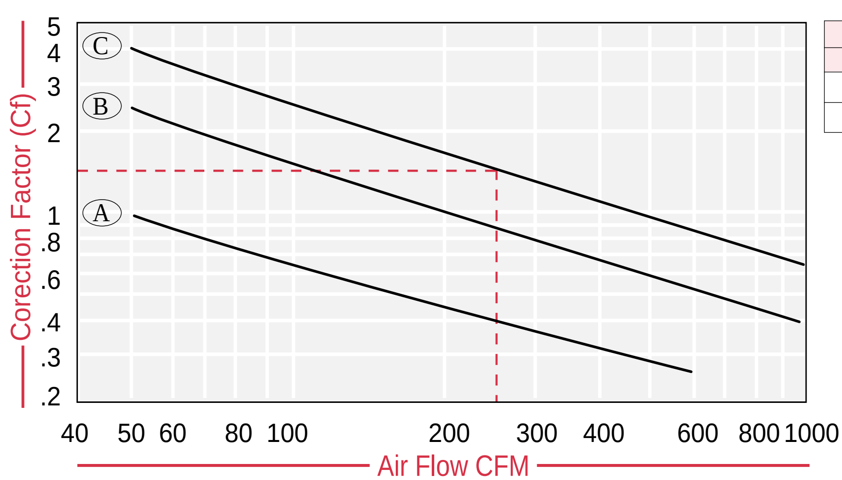
Note: Performance curves are based upon petroleum oil at 50 sus. For average oil viscosities other than 50 sus, use the correction factors Cv & Cp located on page 3. If the above models can not meet your cooling needs, please refer to our fan cooled models.

STANDARD CONSTRUCTION MATERIALS

Standard Construction Materials			
Tubes	Copper	Manifold	Steel
Fins	Aluminum	Mount. bracket	Steel
Turbulators	Steel	Cabinet	Steel

Standard Unit Ratings	
Operating Pressure	300 psig
Test Pressure	450 psig
Operating Temp.	400 °F

Air Flow Correction Chart



ELECTRIC MOTOR NEMA FRAME SIZES

Curve A	Curve B		Curve C
48 - 184	213 - 256	254 - 286	324 - 365
BM - 101	BM - 201	BM - 301	BM - 321
BM - 102	BM - 202	BM - 302	BM - 322

EXAMPLE OF A MODEL

BM - 302 - S

Series

Model
101 , 102
201 , 201
301 , 302
321 , 322

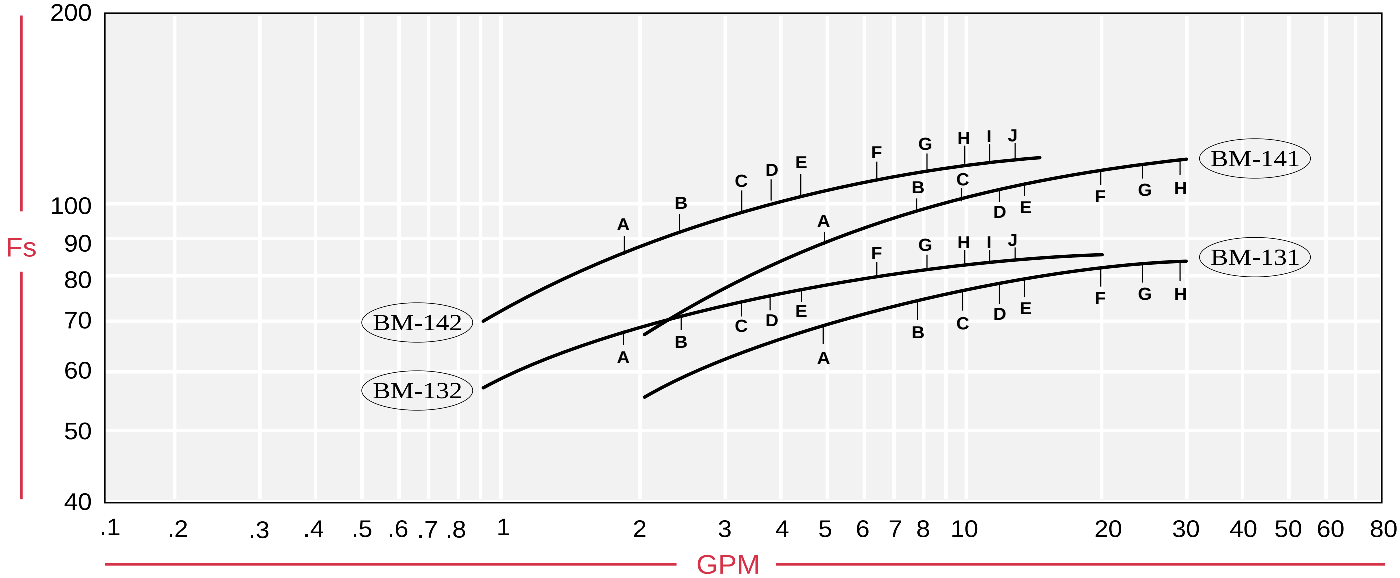
Connections
N = NPT
S = SAE

Use the following formula to correct for airflow rates for the given curves A,B, or C (as it is shown in the above dotted line graph).

Formula
Fs x C*f* = CFs (corrected Fs)

Example
123.7 x 1.50 (from curve) = 185.6 CFs

BM SERIES



PERFORMANCE CALCULATION	OIL PRESSURE DROP (PSI) CODE			
$F_s = \frac{\text{Horsepower to be removed (HP) x 2545 x Cv}}{\text{°F (Oil Leaving* - Ambient Air Entering)}} = \frac{\text{BTU}}{\text{hr °F}}$	A = 1 PSI	D = 4 PSI	G = 15 PSI	J = 30 PSI
	B = 2 PSI	E = 5 PSI	H = 20 PSI	K = 35 PSI
	C = 3 PSI	F = 10 PSI	I = 25 PSI	L = 40 PSI

*Represents desired fluid leaving the cooler.

Sizing
The performance curves provided are for petroleum oil at 50 ssu viscosity. However, fluids with characteristics other than the above mentioned may be used by applying a correction factor.

Heat Load
If the heat load is unknown, a horsepower value can be calculated by first determining the systems total potential. For a basic hydraulic system, it is helpful to know whether the system is open loop (with a large reservoir) or closed loop (normally on mobile equipment, with a very small reservoir). System potentials may be calculated quickly by using one of the two methods below.

There are some system parameters that will be required to properly accomplish the sizing calculations. Without system parameters it is difficult to determine the optimal heat exchanger size. Normally many of the system parameters can be found on hydraulic schematics or on tags located on the actual equipment. Follow are some basic parameters that you should try to acquire before attempting the sizing calculations. However, it is not necessary to have every parameter listed below.

- Main system flow rate (gpm) & operating pressure (psi).
- Electric motor HP driving hydraulic pump (if more than one add up the Hp for all).
- Desired temperature (°F).
- Fluid type (SAE 10, 20, 30, etc....).
- Ambient air temperature (warmest day).
- Desired fan drive (hydraulic, electric, 12-24V DC, etc...).
- BTU's or HP to be cooled (normally given for lubrication systems).
- Maximum pressure drop allowed through the heat exchanger.
- Space available for heat exchanger (LxWxH).
- External air condition (dirty, papers,etc.)

Method 1
Normally used for open loop circuits. Multiply the main hydraulic systems Electric Motor Name plate Horsepower by a heat removal factor (normally 30-50%).

Example: 5 HP motor x .25 = 1.25 HP heat load

Method 2
Normally used when the HP input potential is unknown or for mobile applications where diesel engines operate the entire system.

Multiply system pressure by the flow rate of the main system divided by 1714 equals system potential (HP). Multiply the system HP by a heat removal factor (Normally 25-35%). Note: In some closed loop systems only a portion of the total system flow is directed through the heat exchanger, this may affect the cooler selection process substantially. You may contact our factory for additional technical assistance.

Example: $\frac{\text{(1700 psi x 5 gpm)}}{1714}$ = [5 HP x .25] = 1.25 HP heat load

Determining Fs value
To determine the proper size heat exchanger for your application, use the following equation to first determine the (Fs) factor.

$$Fs = \frac{\{\text{heat load (HP) x 2545 x Cv}\}}{\{\text{°F (oil leaving - air entering)}\}}$$

Example:
Heat load = 1.25 HP
Cv = 1.11 (SAE 20) determined from chart. [Located on page 3.]
Desired operating temperature = 10 ºF
Ambient air temp. = 100 ºF

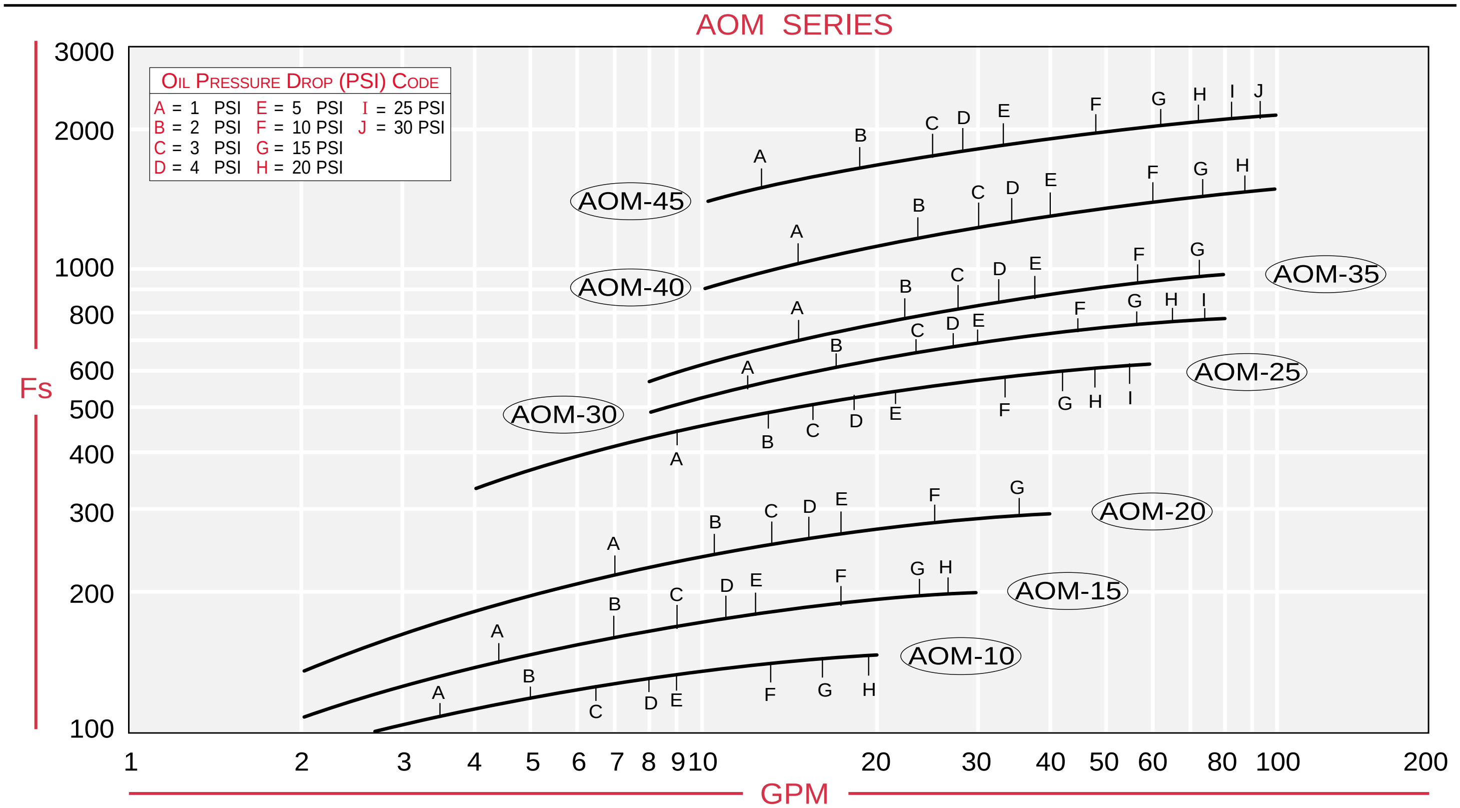
$$Fs = \frac{\{1.25 \times 2545 \times 1.11\}}{\{140\text{ °F} - 100\text{ °F}\}} = 88.3$$

Selection
To select a model, locate the flow rate (GPM) at the bottom of the flow vs Fs graph (on page 4). Proceed upward until the GPM flow rate intersects with the calculated Fs. The curve closest above the intersection point will meet these conditions.

Example: Fs = 88.3 = Model = BM-141
GPM = 5

Pressure differentials
Determine the oil pressure drop from the curves as indicated. For viscosities other than 50 ssu, multiply the actual indicated pressure drop for your GPM flow by the value shown in the pressure differential curve for your viscosity value.

Example: Model 141 @ 5 gpm & 50 ssu -curve-
Indicated pressure drop 1 psi (Approx)
{ 1 psi x 2.23Cp (for SAE-20 oil,page 3) } = 2.23 corrected psi



SELECTION GUIDE

The performance curves are based on 50 sus oil & 1000 Standard Feet Per Minute air velocity. If your air velocity is other than 1000 SFPM, please use the correction curve located on this page before choosing a model.

SIZING

To properly size a AOM air-cooled oil cooler for mobile equipment, first determine some basic parameters associated with your system.

HEAT LOAD

In many instances the heat load must be determined by using the following method. The total potential or horse power method is the most common method, and is the simplest way to determine basic heat rejection requirements for mobile hydraulic systems. The total potential is equal to the maximum operating flow and pressure that are generated by the system under full load. To determine the total potential (HP) use the following formula.

HP = [System Pressure (PSI) x System flow (GPM)] / 1714

Example:
HP = (3000 PSI x 40 GPM) / 1714 = 70 HP or the total input potential

To determine the system heat load in BTU / HR use a percentage *(v)* of the system potential HP. The factor *(v)* can be calculated by adding up the actual inefficiencies of a system; however, for most applications a *(v)* value of 25% - 30% can be used.

Example:
70 HP x .25 = 17.5 HP heat

To convert the horsepower of heat into BTU/HR use the formula below:
HP x 2542 = BTU/HR

Example:
17.5 HP x 2545 = 44,538 BTU/HR

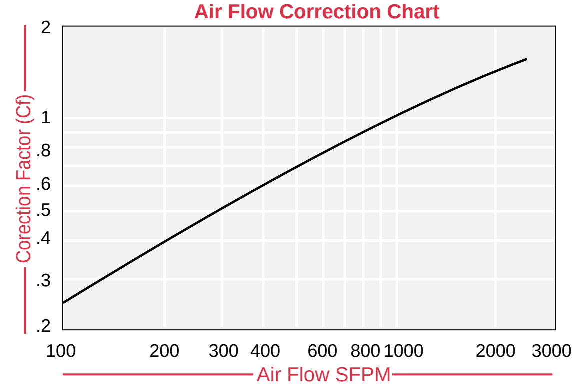
Applying into a return line

For most open loop systems with a vane or gear type fixed delivery pumps. To calculate the Fs value required when applying the air/oil cooler into a return line use the formula below.

$$Fs = \frac{BTU/HR \times Cv}{T - t_{ambient}}$$

T = Desired system oil temperature leaving the cooler °F
$t_{ambient}$ = Ambient air temperature entering the cooler °F
Cv = Correction factor for oil viscosity. Example: ISO32 oil @ 150°F = 1.06 *see chart*

Air Flow Correction Chart



APPLYING INTO A CASE DRAIN LINE

In circumstances where the system is closed loop or when return line flow is not available, the case drain flow can be utilized to help cool the system. However, in many instances, the case drain flow alone will not be enough to reject all of the heat generated by the system. Case drain lines should not be treated as a normal return lines since the pressure drop allowable usually can vary from 2 - 10 PSI max. Check with your pump manufacturer for the appropriate pressure drop tolerance before applying any cooler. To size the system for case flow or case flow plus any additional fluching loops, please use the following method.

Formula

Tc_{exit} = { T - [Q / (case flow gpm x 210)]}

Example

Tc_{exit} = { 150 - [44,538 / (10 x 210)]} = 128.8

Tc_{exit} = The corrected temperature of the oil exiting the cooler.

$$Fs = \frac{Q \times Cv}{Tc_{exit} - t_{ambient}} \qquad \frac{44{,}538 \times 1.06}{128.8 - 100} = 1{,}639$$

CORRECTING FOR ALTERNATE AIR VELOCITY

If your air velocity is other than 1000SFPM, you must correct to achieve the proper capacity required.

Formula : CFs = Fs / Cf